INDOOR AIR QUALITY ASSESSMENT

Francis J. Muraco Elementary School
33 Bates Road
Winchester, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Muraco Elementary School, Winchester, MA. On October 16, 2001, a visit was made to the school by Cory Holmes, Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an assessment. Mr. Holmes was accompanied by Paul D'Elia, School Custodian during the assessment. Reports of exacerbation of asthma attributed to potential mold exposure resulting from flooding prompted this assessment.

The school is a one-story brick-on-cement-slab building constructed in the mid 1960's. The school contains general classrooms, a music room, library, gymnasium, kitchen/cafeteria, several reading/resource rooms and offices. Classrooms are not fully enclosed but are separated into pods by five-foot high dividers. Windows throughout the building are openable, however school staff reported that they are difficult to open in a number of areas (e.g. damaged equipment, missing cranks) (see Picture 1).

The building was previously evaluated by ATC Associates Inc. on August 31, 2001 and a report was issued. The ATC report recommended that: 1) carpets be steam cleaned at high temperatures and vacuumed frequently with a high efficiency particulate arrestance (HEPA) filtered vacuum cleaner; 2) long term planning should include carpet replacement in slab-on grade classrooms; 3) surface dust on univents be cleaned and filters replaced regularly; 4) porous items (e.g., cardboard) and debris be removed from the basement crawlspace; 5) damaged fiberglass insulation be repaired to minimize mold growth opportunities; 6) shrubs obstructing intake vents be trimmed; 7) consideration should be given to increasing ventilation and placing a plastic vapor barrier over the crawl space dirt

floor; and 9) the disinfection of insulation surfaces that are stained (ATC, 2001). The MDPH assessment was conducted several weeks after that report was issued.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses pre-kindergarten through fifth grade. It has a student population of approximately 400 and a staff of approximately 80. Tests were taken during normal operations at the school and results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in four of twenty-six areas surveyed, indicating adequate fresh air ventilation in most areas of the school. It is important to note however, that a number of areas were sparsely populated or had open windows, which can greatly contribute to reduced carbon dioxide levels. The MDPH approach to resolving indoor air quality problems is primarily two-fold: 1) improving ventilation to dilute and remove environmental pollutants and 2) reduce or eliminate exposure opportunities from materials that may be adversely affecting indoor air quality.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the

building (see Picture 2) and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. It was reported that univents are normally not activated until the start of the heating season. BEHA staff explained that these units not only provide heat but are designed to provide a constant source of ventilation. After discussion, school maintenance staff reactivated univents. Univents were operable in all areas after activation, however the unit in the teacher's lounge repeatedly deactivated, indicating a mechanical malfunction. Also of note was the univent in classroom K-2. Although the unit was operating on the "high" setting it was producing very little airflow. Lack of airflow can indicate a mechanical problem with the univent. To function as designed, these units must be activated and allowed to operate during hours of school occupancy.

The mechanical exhaust ventilation system consists of wall-mounted exhaust vents. No draw was detected in classrooms K-1 & K-2, which can indicate that either the exhaust ventilation was turned off, or that rooftop motors were not functioning. A number of exhaust vents were obstructed by tables, chairs, boxes and other items (see Picture 3). The location of some exhaust vents can also limit exhaust efficiency when the classroom hallway door is open (see Picture 4). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Without removal by the exhaust ventilation, normally occurring environmental pollutants can build up and lead to indoor air complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be

balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature measurements ranged from 69^{o} F to 75^{o} F, which were mostly within the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 35 to 45 percent, which was slightly below the BEHA recommended comfort range in some areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

At the time of the BEHA assessment no standing water or visible mold growth was observed in the basement/crawlspace. As per the recommendation of ATC, the basement/crawlspace was cleaned out and storage of materials in these areas was discontinued.

Spaces between the sink countertop and backsplash were noted in a number of classrooms (see Picture 5). A leaking faucet was noted in classroom 9. Repeated leakage or improper drainage/overflow of water in sinks can lead to water penetration/damage of countertop wood, the cabinet interior, areas behind cabinets and carpeting. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Along the perimeter of the building, shrubbery and flowering plants were noted in close proximity to univent fresh air intakes (see Picture 6). Shrubbery and flowering plants can be sources of mold and pollen and should be placed and/or maintained to ensure that fresh air intakes remain clear of obstructions to prevent the entrainment of dirt, pollen or mold into the building. In addition, plants can hold water against the exterior of the building. Over time freezing/thawing action during the winter can weaken bricks and mortar, resulting in damage to the building envelope.

The faculty lounge and nurse's office contained a water cooler and a sink mounted over carpeted floors. Water stains were noted around the water cooler in the faculty lounge (see Picture 7). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain chemicals (such as bleach or ammonia related compounds), which can also be irritating to the eyes, nose and throat and should be stored properly out of reach of students. In addition, a number of classrooms contained unlabeled spray bottles. Products should be kept in their original containers or should be clearly labeled as to their contents, for identification purposes in the event of an emergency.

Also of note was the amount of materials stored inside some classrooms. Items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amounts of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g. papers, folders, boxes, etc.) make it difficult for custodial staff to clean around these areas. Household dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

1. Implement the recommendations made in the ATC report (ATC, 2001).

2. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy year round. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
3. Examine rooftop exhaust motors for proper function. Repair/replace belts and parts as necessary.
4. Consider having the systems balanced by an HVAC engineering firm.
5. Remove all obstructions from univents and mechanical exhaust vents to facilitate airflow.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Repair leaky faucet in classroom 9.
8. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard behind cabinets for water-damage and mold growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed.
9. Inspect plant growth outside perimeter of building periodically; trim plant growth away from fresh air intakes as needed.

10. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

11. Store chemicals and cleaning products properly and out of the reach of students. Ensure products are properly labeled in the event of an emergency for identification purposes.

References

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

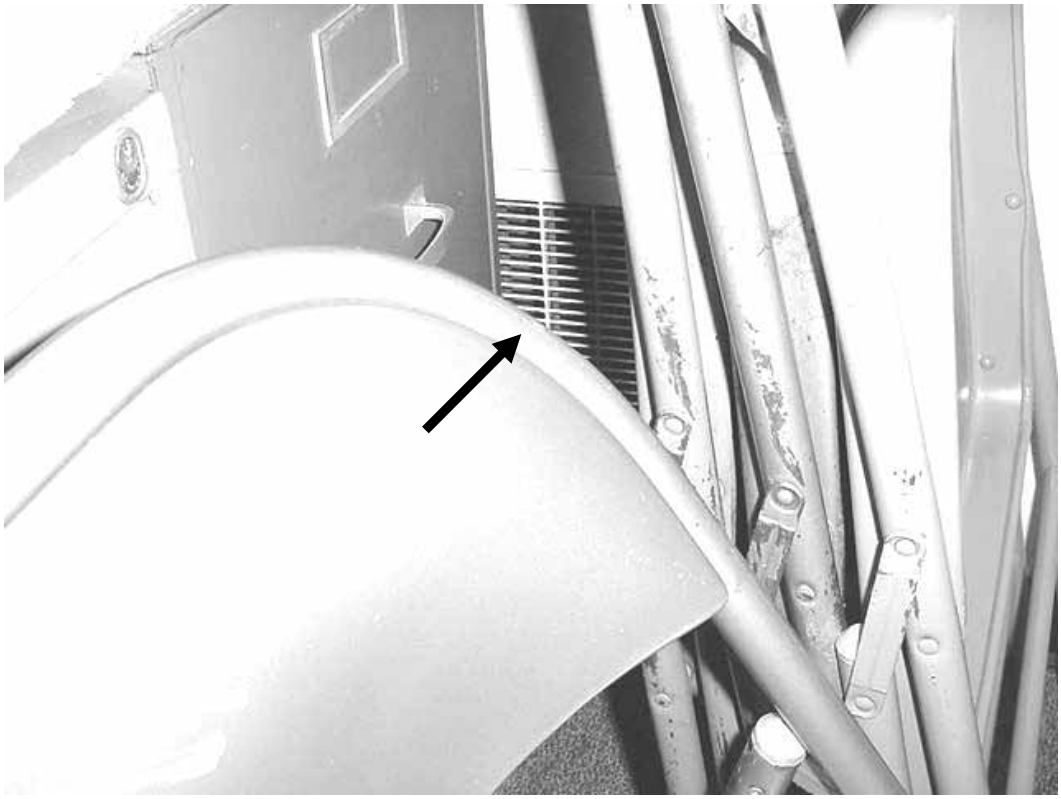
Picture 1

Wall-Mounted Window Control Mechanism, A Number of Which Were Non-Functional or Difficult to Operate

Picture 2

Univent Fresh Air Intakes

Picture 3

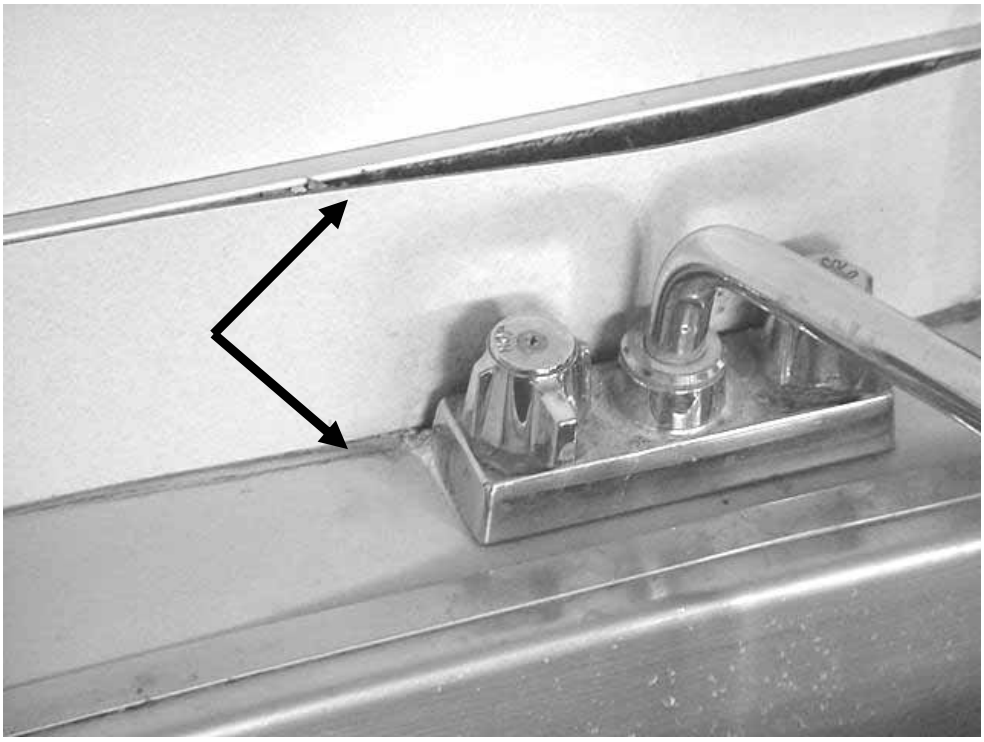


Obstructed Classroom Exhaust Vent

Picture 4

Classroom Exhaust Vent behind Open Door

Picture 5



Spaces around Classroom Sink and Backsplash

Picture 6

Shrubbery Obstructing Univent Air Intake

Picture 7

Water Stained Carpet under Water Cooler

TABLE 1

Indoor Air Test Results – Muraco Elementary School, Winchester, MA – October 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	413	73	31					Weather conditions: clear skies-sunny, light breeze
Music Room	566	75	41	0	Yes	Yes	Yes	Exhaust vent blocked by chairs/desk
Room 17	732	74	38	14	Yes	Yes		Door open, 2 plants
Room 9	632	72	41	19	Yes	Yes	Yes	Door open, leaky faucet
Room 8	740	73	37	2	Yes	Yes	Yes	
Room 7	577	72	35	14	Yes	Yes	Yes	Window and door open, exhaust vent behind door
Pod B (Computer Room)	782	73	40	9	Yes	Yes	Yes	Passive supply, 13 computers
Room 10	764	72	40	0	Yes	Yes	Yes	Spaces around countertop
Room 11	864	73	40	21	Yes	Yes	Yes	Spaces around countertop
Room 12	820	72	39	0	Yes	Yes	Yes	
Nurse	609	70	44	3	No	Yes	Yes	Sink over carpet

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results – Muraco Elementary School, Winchester, MA – October 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Resource Room	569	71	42	2	Yes	Yes	No	Items on univent
Teacher's Lounge	964	73	45	11	Yes	Yes	Yes	Water cooler on carpet-water stains, univent cycles
Library	648	74	41	0	Yes	Yes	Yes	
Reading Room	542	74	38	0	Yes	Yes	Yes	
Teacher's Workroom	632	75	39	1	No	Yes	Yes (2)	2 photocopiers, 2 lamination machines, passive supply
Room 18	596	72	38	9	Yes	Yes	Yes	Window and door open, exhaust vent behind door, window cranks broken
Room 6	676	72	40	4	Yes	Yes	Yes	Paint under sink
Room 5	693	71	41	5	Yes	Yes	Yes	Exhaust vent partially blocked
Room 4	658	71	41	1	Yes	Yes	Yes	Spaces around sink
Room 3	557	71	39	0	Yes	Yes	Yes	

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TABLE 3

Indoor Air Test Results – Muraco Elementary School, Winchester, MA – October 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 2	563	71	40	0	Yes	Yes	Yes	
Room 1 (OT)	559	72	41	0	Yes	Yes	Yes	Cleaning product on sink
Cafeteria	880	73	42	~200	Yes	Yes	Yes	
K1	711	71	41	10	Yes	Yes	Yes	Cleaning product/unlabelled spray bottle under sink, floor univent, spaces around sink/countertop, exhaust fan off
K2	674	70	41	17	Yes	Yes	Yes	Exterior door open, univent on "high"-low air-flow, exhaust off
Art Room (19)	563	69	41	0	Yes	Yes		Univent off, spaces around sink/countertop
Basement/ Crawlspace								Dirt crawlspace, no standing water, no remaining water damage, cleaned in October
Perimeter Notes								Wasp nest-rear of building, shrubbery blocking air intake of music room

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